Edith Whetnall's contribution to British audiology[1]

H A Beagley FRCS DLO
Nuffield Hearing and Speech Centre,
Gray's Inn Road, London WC1

It is a great honour for me to have been invited to deliver the third Edith Whetnall Memorial Lecture for two reasons: first, because the two previous lectures were given by very distinguished personalities, Professor Dennis Fry and Professor William Hardy; and secondly, because I was once a pupil and later a colleague of Edith Whetnall, whose persistent and successful efforts on behalf of her young hearing-impaired patients and whose zeal and visionary approach to the problems of the deaf have been so emphatically vindicated and widely accepted and adopted, both nationally and internationally.

I first met Edith Whetnall as a postgraduate student at the Institute of Laryngology and Otology in 1949–1950 when she was a young assistant otological surgeon at the Royal National Throat, Nose and Ear Hospital. Even then, she was deeply concerned with the problems of the deaf, and in particular with the problems of deaf children, especially those born with defective hearing. Edith Whetnall already had considerable insight into these problems, having previously been for some time honorary clinical director of the MRC's Wernher Unit which, under the late Dr Tom Littler, was responsible very largely for the development of the now well-known Medresco hearing aid. It was the issue of these aids on a large scale that brought help to the many hearing-impaired adults for whom very little other prospect of relief of the handicap of deafness then existed. Many of these patients suffered from conductive hearing loss resulting from chronic otitis media or advanced otosclerosis, and it is interesting to recall that at that time it was thought that only these cases would benefit from a hearing aid. A hearing aid was thought to be of little use in cases of sensorineural hearing loss. Although undoubtedly conductive hearing loss was relatively easy to treat by means of amplification, the fact that sensorineural hearing loss could also be relieved in this way took longer to establish. However, Edith Whetnall and her associates achieved an extraordinary degree of success using amplification in the management of young children, and even babies, affected by quite severe degrees of sensorineural hearing loss.

As she was considerably hampered by ill-health, Edith Whetnall gradually withdrew from the practice of otological surgery and devoted herself increasingly to what we now call audiology – that is, the diagnosis and nonsurgical management of hearing loss. Conductive hearing defects have remained in the province of the otological surgeon: the success of the surgical management of otosclerosis, of chronic catarrhal deafness or 'glue ear', of the plastic reconstructions of the middle ear following chronic middle ear disease ('tympanoplasty'), and reconstructions of traumatic lesions of the middle ear mechanisms, all attest to the considerable achievements of the otological surgeons in combating deafness. However, when one considers that in sensorineural hearing loss the essential lesion is located either in the

[1] Edith Whetnall Lecture to Section of Otology, 5 May 1977

0141–0768/78/120870–09/$01.00/0

cochlea itself or in the cochlear nerve, it is not difficult to see why surgery offers only limited prospects of success.

Although trained as an otological surgeon, Edith Whetnall was not deterred by the somewhat bleak prospects of relieving sensorineural hearing loss. With vigour she set about initiating the provision of hearing aids as well as supportive programmes such as lip-reading classes. Originally these activities were concentrated in a clinic at Golden Square Hospital, then called the Deafness Aid Clinic, which was first established in 1947, one year before the birth of the NHS. This clinic grew steadily and was eventually transferred to the Gray's Inn Road branch of the Hospital as the Audiology Unit, of which Edith Whetnall was Director.

Impressed by the severity of the handicap suffered by young children with severe sensorineural hearing loss, in particular the total lack of verbal communication to which this condition could lead, Edith Whetnall began to apply to these infants the idea of amplification by means of hearing aids. Possibly she was herself rather surprised by the readiness with which children would accept and wear a hearing aid – but in any case she persisted with this approach, although this was perhaps regarded with a degree of scepticism by some of her colleagues.

It became clear to her that early diagnosis of such congenital cases was the key to their successful management. Today this may seem trite, but in 1950 it was not generally appreciated that it was most unwise to procrastinate when faced with a case of possible hearing loss of congenital origin. Indeed it was part of Edith Whetnall's philosophy that all, or practically all, children who were clinically deaf had a useful residuum of hearing which could be exploited by early diagnosis and appropriate management. Edith Whetnall's sweeping generalizations on this point have proved to be amply justified in view of the fact that only a minute fraction of deaf children are totally deaf, and these usually as a result of bilateral cochlear agenesis or severe complications of cerebrospinal meningitis. It is now generally accepted that some residual hearing almost always exists, and sometimes this remnant of hearing is very useful indeed; but without early diagnosis and management such children were virtually doomed to a life of little or no verbal communication or even muteness.

It was another of Edith Whetnall's precepts that a congenitally deaf infant should be fitted with a hearing aid in the earliest months of life in order to give the child his best chance of achieving usable hearing and speech skills – and once again this sweeping assertion has been justified by knowledge gained subsequently. It was Edith Whetnall's passionate insistence that early management be instituted without delay, even in the first few months of life, that has led clinicians to the realization that early correction of a hearing loss is indeed necessary if a successful rehabilitation is to be achieved, with the child developing usable speech, able to communicate in the world at large, and able to receive a worthwhile education.

During the 1950s Edith Whetnall became increasingly concerned with the problems of deaf children and concentrated her time and attention increasingly on young patients. A clinic dealing solely with deaf children was established and housed in various parts of the hospital in Gray's Inn Road, but finally in 1962 it was housed in the fine premises now known as the Nuffield Hearing and Speech Centre, established very largely by a grant from the Nuffield Foundation, the result it is said of Edith Whetnall's eloquent advocacy of the deaf child to the late Lord Nuffield, the well known industrialist and philanthropist. From that point Edith Whetnall became the Director of the Nuffield Hearing and Speech Centre.

It would be understating the case to say that the Nuffield Centre has become widely known as a result of Edith Whetnall's espousal of what has become known as the 'auditory' method of managing and teaching severely deaf children. It will be remembered that, hitherto, there were two main and somewhat conflicting philosophies of educating deaf children: one was the manual method, sometimes known as the French method, associated largely with the name of the Abbé de L'Epée; and the other was the oral method, sometimes known as the German method which was based on lipreading and associated with the name of Samuel Heinicke. The pros and cons of these two conflicting view points are widely understood and to some extent they are irreconcilable. It is accepted that children taught by the manual method learn more

but communicate less than those taught by the oral method, the reason being that they can communicate only with others who are themselves fluent in manual language. Nevertheless, it is quite widely used as an educational technique, e.g. the Gallaudet College in the USA which gives higher education largely based on these methods. Oral education, on the other hand, by promoting lipreading as the primary method of communication, permits a child so educated to communicate more successfully with hearing persons than does the manual method. Today, of course, attempts are being made to combine these two different methods.

But Edith Whetnall's philosophy of 'auditory' method of education cuts across both these classical procedures. It is based on the use of residual hearing from a very early age by means of amplification from hearing aids. This method, successfully applied, results in the development of the child's speech, making use of the important auditory feedback loop, whereby the child can hear and regulate his own voice by virtue of the amplification of the hearing aid, thus making the best use of what auditory clues are available, imperfect though they may be.

The final postulate in Edith Whetnall's philosophy was that as far as speech is concerned the child's main teacher should be his mother. When one considers that the hearing child learns to speak a few words in his second year of life and is quite fluent by school age, and that his principal teacher is his mother, the rationale of this viewpoint is readily understandable. Thus, early diagnosis, early provision of hearing aids, and instruction and support for the mother of the hearing-impaired infant, so that speech is acquired at a realistically early age, are the basis of Edith Whetnall's success in dealing with deaf infants. Support for the mother took many forms: explanation and instruction in the realities of hearing loss (sometimes called family counselling), the ways in which it can be minimized, the importance of continuous use of the hearing aid, and the necessity of a large volume or flow of verbal communication from the mother to the child. The mother is expected to explain verbally everything she does when, for example, doing the household chores when followed about by her deaf toddler. She is urged to speak clearly and distinctly, facing the child as much as possible and as often as possible with her face on a level with the child's so that he can see her facial expressions and lip movements. Although obvious, the instructions must repeatedly be stressed to the mother. Such maternal instruction is given at the Nuffield Hearing and Speech Centre and by week-long residential courses at the Ealing Hostel for Mothers and Babies, where instruction is given by teachers of the deaf, speech therapists and psychologists. Such courses have proved extremely beneficial to many mothers of deaf children – and fathers too, for they are welcome to attend. Other support for the mother's efforts includes early admission of the deaf toddler to a normal-hearing play group or nursery school where the normally highly vocal, noisy children without hearing defects do a great deal to stimulate the hearing-impaired child's vocabulary at a level appropriate to his age. In addition, the mother can attend weekly or twice-weekly sessions at the Nuffield Centre, if she lives locally. Alternatively the local authority is advised to allot a peripatetic teacher of the deaf to the case; this teacher will visit the child in his home and continue the programme of auditory training. According to Edith Whetnall, if such a technique were to be followed the child would be capable, in almost every case, of being educated in a normal school – or at the very least in a partially-hearing unit of a normal school. While this assertion is perhaps too sweeping, it is nevertheless substantially true and is the goal at which one should aim. Many deaf children managed in this way have developed clear and intelligible voices, fluent spontaneous speech and have achieved high educational standards, some being able to win university places and enter the professions. Edith Whetnall's auditory method, which can be regarded as an augmented form of the classical oral method, does not segregate the child from the rest of the hearing community; this is its great advantage, and it is often strikingly successful. The method has been taken up extensively on the national scale and also has many advocates abroad.

The Institution Nationale des Sourds-Muets in Paris was founded by the Abbé de L'Epée (1712–1789), a leading exponent of his time of the manual method of teaching the deaf. It is probably not surprising that the institute he founded was called the Institution for Deaf-Mutes; children taught by this method were likely to be mute as communication is not

channelled through the auditory system at all and the voice does not develop. Recently I had the privilege of visiting the Institution which is housed in an elegant historic building in a beautiful garden. Although the buildings have a look of antiquity, children are now taught by an essentially auditory method using the most up-to-date teaching aids including radio-linked group aids of which Edith Whetnall would have approved.

The older children are also well catered for with vocational training being given in printing and electronics. Hearing-impaired children, as school-leavers, do well in the field of specialized printing, including colour printing, and the Institution trains them on the most modern printing presses. A similar activity is the instruction of older children in the assembly of the more specialized electronic circuits, which has to be done by hand; the more conventional assemblies – television sets, etc. – are usually automated, but the deaf youngster can do the manual assemblies required for specialized applications – reading circuit diagrams and soldering the components. In addition, they also build and repair audio equipment and hearing aids used within the Institution which, incidentally, has commercial contracts both for specialized printing and for electronic assemblies, so that the instruction is not given in an atmosphere which is out of context with the outside world where the pupil must eventually make his way. The placement of hearing-impaired school leavers is a difficult problem in the UK, and the Paris experiment may well have something to commend it.

The city of St Louis in the USA, named in honour of the crusader King Louis IX of France, is also a well known and important centre for auditory research. It is here that the Central Institute for the Deaf is situated, founded by the late Dr Max Goldstein who also founded the medical journal *Laryngoscope*. He also established a school for deaf children here. Drs Hallowell Davis and Lorento de No are amongst the distinguished people who have been associated with the Institute. The Infant Progress House at the Institute is an interesting building adapted to a purpose which would have pleased Edith Whetnall immensely; in fact it was so adapted for Dr Audrey Martin-Simmons who is a great admirer of Edith Whetnall and her methods. The building is, and looks like, a house – but it is a little different in some ways. For example, it has several kitchens each of which can be used as an informal classroom for a mother and her hearing-impaired child and their teacher, so that the auditory training can be given in realistic surroundings, e.g. helping mother to make a pie or a cake, or wash up, etc. The subtle use of perforated zinc screen doors – essential in the St Louis climate – allows observers to watch and listen, and for more detailed supervision there is a closed-circuit television link. This house, and the methods employed in it, were partly inspired by and in some ways are similar to the Ealing hostel established by Edith Whetnall.

Importance of early diagnosis

Early diagnosis of hearing loss depends on two main factors: first, suspicion on the part of the clinician (or parents or others) that a hearing deficiency is possible; and secondly, some form of clinical assessment of hearing. The usual way of assessing a young child's response to sounds, and thus his state of hearing, is by the use of distraction tests of the type popularized by Sir Alexander and Lady Ewing of Manchester University. These tests are easily and quickly performed by an experienced tester and give immediate qualitative information on the state of the child's hearing. Such tests, of course, depend upon the child's tendency to seek the origin of a sound that he hears and it is the head-turning response that the tester notes as being a positive response to sound.

Although very simple to use, the best results are, naturally, obtained by a highly-skilled tester who will not be deceived by false-positive responses on the one hand and by the absence of a response due to various causes on the other: e.g. excessive attention being paid by the child to the assistant whose task it is to attract the child's gaze, or habituation, which can occur rapidly in some cases, or muscle weakness which is a potent cause of error in a child only a few months old, who may have poor muscular head control.

It goes without saying, therefore, that the more skill the tester has in handling young children, the better will be the results obtained by the use of these methods. An experienced

tester will be aware that a young infant of perhaps five or six months of age, who fails to respond, may respond briskly a month later. Such retesting is perfectly reasonable, but it should not be allowed to lead to procrastination in making a firm diagnosis.

There are always some children who are extremely difficult to assess by clinical tests based on distraction. Obvious cases are those who have highly defective vision, suspected deaf-blind infants, or those with muscular spasms or tics, or conversely those with muscle weakness. Both of these categories may give rise either to false-positive or false-negative results. Children who are hyperactive, emotionally disturbed or grossly retarded also may be extremely difficult to diagnose by the use of classical distraction tests.

Although the classical Ewing-type distraction tests are the mainstay of the clinical assessment of hearing of infants, there exists a small proportion of children in whom such tests will fail. It also goes without saying that a large centralized clinic for the assessment of potentially hearing-impaired children, such as the Nuffield Hearing and Speech Centre where over 1000 new cases are seen annually, will attract a disproportionate number of such difficult cases.

Edith Whetnall was well aware of this problem and anxious to find a way around it. In 1963 she was invited to attend an international symposium in Toronto on 'The Early Diagnosis of the Deaf Child', which was sponsored jointly by Drs Ireland and Hallowell Davis. Part of the reason for this meeting was to consider the place of the newly introduced form of so-called 'objective' testing of hearing based on the auditory evoked cortical potential (AEP). It may not generally be realized that Edith Whetnall was associated with the introduction of electrophysiological tests of hearing; in fact she had a keen interest in such developments.

I joined the Nuffield Hearing and Speech Centre in 1964, about one year after the Toronto conference, and prior to that I had been working with Dr Eldredge, Dr Davis and others at the Central Institute for the Deaf in St Louis where some of the pioneering work on the AEP was being undertaken. Upon taking up my present post at the Nuffield Centre Edith Whetnall and I set about finding ways of implementing such procedures. Applications to the various fund-granting bodies were at first unsuccessful, but finally I had the good fortune to receive a grant for this purpose from the National Deaf Children's Society (NDCS) and in this way the AEP was used as a clinical hearing test for the first time in this country. Since then I have had support from other organisations such as the MRC, the Spastic's Society and the Ewing Foundation, but I am especially grateful to the NDCS for the valuable support extended to me at various times over the last ten years which has permitted electrophysiological tests of hearing to be developed at the Nuffield Centre.

At first, the test used mainly in this context was based on the AEP, often called evoked response audiometry, or more correctly electric response audiometry; the former title is considered to be tautological and has largely been replaced. Electric response audiometry (or ERA as it is often called) proved to be a great help in many of the difficult diagnostic problems which faced us, but it also was beset by a number of difficulties in the case of young children, in whom the need for diagnosis was the most urgent.

It seems that the immature cortex of the infant and the large amplitude slow rhythms that it produces could cause serious problems with the averaging technique used to extract the cortical potential. In addition, movements of the head gave rise to serious artefacts of muscular origin which could lead to wrong conclusions. For this reason ERA, especially in the hands of enthusiasts, acquired a poor reputation on the basis of its relative unreliability. For my part I would like to think that I avoided the worst of these problems by adhering to a certain principle for which I am grateful to Edith Whetnall. This was that, when in doubt about the hearing status of a child, it is better to err on the side of pessimism and to treat the child as if he were deaf. If in the future the diagnosis were changed for the better, if it was later discovered that the child could in fact hear, then any management he may have been given, including a hearing aid, while it may have been futile, would in no way have been harmful. The opposite situation could, of course, be disastrous as a child who was deaf would not get any suitable treatment at all, or not until it was too late to be of any real value.

I always applied this reasoning to ERA. Only if I could identify an AEP unequivocally and repeatedly was I prepared to report that the child could hear. An occasional response, or possible response, which could have been an artefact, did not provoke me into reporting that the child could hear, and I erred on the safer side – that of reporting a hearing loss. This strong bias arose from some specific clinical examples demonstrated to me by Edith Whetnall, and as a result of such intentional bias in what I like to call the 'right' direction I believe I was able to avoid the worst errors that may occur when interpreting ERA traces. I feel that if such scepticism had been more generally developed by some other experimenters with ERA, the reputation acquired by the method for unreliability may never have been acquired at all.

Although ERA was very helpful in many difficult diagnostic cases, there were always some reservations about its usefulness in very young children, in spite of its obvious merits. These arose from the fact that the AEP, when clearly identifiable, could be traced down to the region of the subjective threshold and at any of the audiometric frequencies normally used. In this way an ERA audiogram could be constructed which was directly comparable with other audiograms. On looking back over old case notes of children tested seven and eight years ago and comparing them with the valid pure tone audiograms now available, I am generally gratified by the accuracy of the opinions recorded following ERA. However, I remain aware of certain doubts at the time of giving the opinions referred to following ERA and feel that much of the success in returning a realistic appraisal of the child's hearing was due in part to extreme caution and determination not to overstate the case and this cautious approach appears to have paid off.

One of the most difficult problems with ERA based on the AEP was in children with disorders such as epilepsy, for obvious reasons, and children with much irregular muscular activity, e.g. habit tics or convulsive or clonic spasms – or simply the restlessness due to gross hyperactivity and for this sedation and testing during sleep was undertaken, generally using i.m. promethazine. This worked after a fashion, but another uncontrolled factor was introduced which further increased the variability of the test. We had already established that full surgical anaesthesia would abolish the cortical response and was therefore unsuitable for our purposes. Thus, with a whole catalogue of unsuitable cases, it became steadily more evident that audiometry based on the AEP was useful mainly in older subjects: in older children for such conditions as nonorganic hearing loss (NOHL) which is surprisingly prevalent, although not particularly serious; and in adults for medicolegal purposes to give some estimate of the validity of conventional audiograms, when these seemed unrealistic.

At the present time, therefore, ERA is virtually restricted to the latter two indications, and the electrophysiological test which has replaced it as the sheet anchor, diagnostically, in difficult or multiply-handicapped, deaf-blind, retarded or hyperactive children, is transtympanic electrocochleography (ECochG).

This test, which was attempted in the 1950s, but reintroduced some fifteen years later by Yoshie & Ohashi (1969) in Matsumoto in Japan and by Portmann *et al.* (1968) in Bordeaux in France, and which uses the technological development of electronic averaging, appears to be the test of choice for such children. The reason for this is that general anaesthesia does not abolish the response, which is an enormous clinical advantage, and the response itself, which is the compound action potential of the cochlear nerve, recorded from a transtympanic needle electrode on the promontory of the middle ear where it lies immediately above the important basal turn of the cochlea, is an easily identified and reliable indicator. The usual stimuli are wide-band clicks, or high frequency tone pulses of various sorts. One of the limiting factors with ECochG is that frequency specificity is poor for the low frequencies, but research that we have in hand may lead to an improvement in this direction. So, while frequency specificity is rather poor, sensitivity and reliability of the test is high and the recordings obtained are derived mainly from the important basal (and middle) cochlear turns, so often the site of the cochlear lesion. A positive response (Figure 1) which can be traced down to a low level in the vicinity of subjective threshold, can confidently be reported as evidence of normal cochlear and neural function; the absence of such a response is, similarly, strong evidence of severely depressed

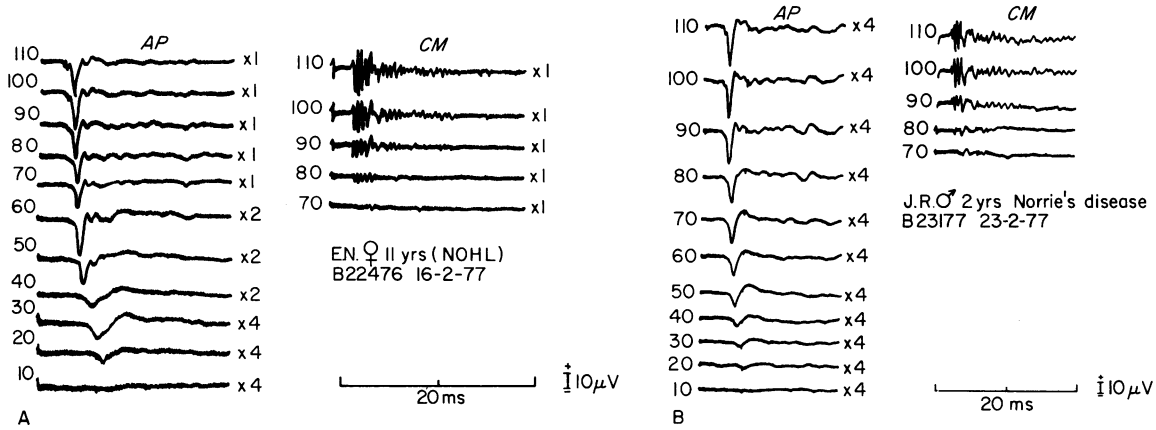

Figure 1. Normal electrocochleograms: A, from a child with nonorganic hearing loss; B, from an infant with Norrie's disease. (AP, action potential; CM, cochlear microphonic)

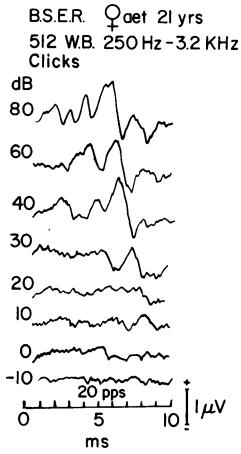

Figure 2. Brainstem response from a young normally-hearing adult

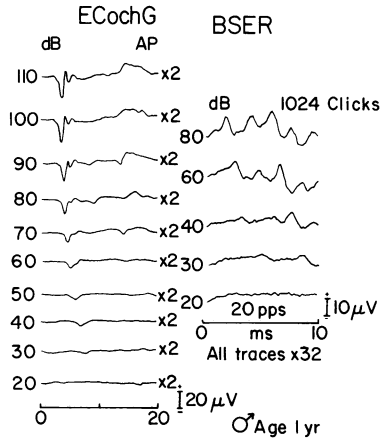

Figure 3. An electrocochleogram together with brainstem responses, both recorded under general anaesthetic

cochlear and neural function – although any low tone remnant from the apex of the cochlea cannot at present be accurately assessed – and on this basis the child will be fitted, correctly, with a hearing aid and treated as a deaf child.

To date we have tested some 1200 cases (over 2000 ears), the great majority being children tested under anaesthesia without untoward incident, and I regard the method, if correctly performed, as being extremely safe. (It has also been very useful in the diagnosis and differential diagnosis of acoustic neuroma and unilateral Ménière's disease in adults.)

Some criticism, generally uninformed, has been voiced concerning transtympanic ECochG. On the matter of the penetrating electrode, I can only say that in 2000 applications I continue to be impressed by the lack of complications, but of course some otological expertise is essential. On the matter of the necessity of general anaesthesia, I can only regard this as a positive advantage, the absence of which, in many of the cases we are called upon to assess, would mean that no satisfactory test could be undertaken. It is probable that ECochG will remain an important aspect of paedoaudiology for many years to come.

There is, of course, a whole range of electrophysiological tests available today and I would like to mention just two other categories:

Reflexes: These include stapedial reflexes which are elicited by the use of the acoustic impedance bridge, especially if the sensitized method of using filtered noise bands according to Niemeyer & Sesterhann's (1974) technique is employed; and the postauricular myogenic response, which has rather oddly been renamed the 'crossed acoustic reflex' by some of its devotees – oddly, because there are several acoustic reflexes and all of them are crossed. Methods of hearing testing based on these reflexes are certainly feasible, if of more limited application, and we and those in other centres today make use of them to a greater or lesser extent.

Brainstem responses: In this test, which was devised by Sohmer & Feinmesser (1973), minute electric waves from the auditory nerve and brain-stem nuclei are recorded from scalp electrodes. There are a series of waves, five in all, arising respectively from the cochlear nerve, the cochlear nucleus, the superior oliviary complex, the nucleus of the lateral lemniscus and the inferior colliculus. The first two are homolateral while the remaining three are bilaterally represented. The fifth wave, from the inferior colliculus region is the most stable and easiest to identify – the earlier ones having a tendency to be rather labile. Figure 2 is from a normally-hearing young adult and the fifth wave can be traced down to about 10dB in her case, but 20dB or even higher may be a more realistic level in many cases.

The great advantage, which may eventually outweigh its variability in the long run, is that it is a noninvasive technique unlike ECochG; but like ECochG it is similarly resistant to sedation and possibly also anaesthesia although this point has yet to be clarified. It is rather less sensitive than ECochG, but has similar frequency specificity. Whether or not it will ever replace transtympanic ECochG is a moot point. The invasiveness of the latter constitutes a grossly over-rated drawback. It is undoubtedly more repeatable, more reliable and more sensitive on the whole, and the anaesthesia required for ECochG would be desirable for the brainstem test in many cases.

To clarify this point it is my intention to carry out a trial where all those children who are assessed by ECochG under anaesthesia will also be investigated at the same session by the Sohmer brainstem method. This will in fact be a sort of controlled trial of one method against the other and the outcome should be interesting. Figure 3 shows such a comparison. Brainstem responses, of course, have an important application in neurological diagnosis, e.g. of multiple sclerosis, but here we are considering only its applicability in paedoaudiology.

We are sometimes asked whether all this electronic wizardry is really worthwhile, much in the way that the usefulness of computers, for example, is sometimes queried – or intensive care units for that matter. Such questionings are usually the result of frustration arising from unrealistic expectations. Implanted electronic cochlear prostheses are the subject today of what may be regarded as unrealistic expectations. It must be clear to us all that at present such devices have extremely limited possibilities when one considers the complex and only partially understood transduction process of the cochlea and the extremely complex speech signals which would have to be encoded by any implanted device. Yet the electronic prosthesis that is implanted in the external auditory meatus, the humble hearing aid, has proved to be a most valuable device and one which Edith Whetnall and others have exploited to the full for deaf children. No one, of course, loves his hearing aid very much, just as no patient much cherishes his crutches, or wheelchair, or other prosthesis. Such a device is a constant reminder of his infirmity, but if it is reasonably efficient and not unduly restrictive it will be accepted with reasonable grace, or at the worst, with resignation.

What we need for the treatment of cochlear or neural deafness is some drug or enzyme or other active principle which will stimulate the regeneration of neuroepithelial elements of the damaged or degenerated cochlea, and auditory nerve. Before dismissing this as hopelessly unrealistic, which of course it is at the present time, we should remember the unusual properties of the nerve growth factor (NGF) discovered by Levi-Montalcini (1964) which resulted from the effect of salivary gland extract, or even more so, from snakes' venom added to a culture of

embryonic tissue. These substances lead to enormous growth of neurones of sympathetic ganglia, and the active principle of this reaction when extracted was found to be a polypeptide which could later be synthesized. If such an unexpected or fundamentally different biological result could be achieved in respect of one particular type of neural tissue, it is not unrealistic to suppose that other such active substances may one day be found by research workers carrying out fundamental biological research. This is one of the reasons why fundamental rather than applied research is more likely to produce such dramatic advances, albeit in a completely unpredictable way. But as long as workers in the field of fundamental research continue their study of basic biological problems, and others apply their discoveries to the relief of deafness, one can anticipate progress to be made towards this goal; mostly it will be plodding step-by-step progress, but punctuated at irregular intervals by occasional rapid spurts. Despite the difficulties posed by the basic problems of deafness, we should remain optimistic.

References

Levi-Montalcini R (1964) *Annals of the New York Academy of Sciences* **118**, 149
Niemeyer W & Sesterhann G (1974) *Audiology* **13**, 421
Portmann M, Aran J M & Le Bert G (1968) *Acta oto-laryngologica (Stockholm)* **65**, 105
Sohmer H & Feinmesser M (1973) *Audiology* **3**, 167
Yoshie N & Ohashi T (1969) *Acta oto-laryngologica (Stockholm)* **71**, Suppl. 252